

CLAIMS

What is claimed is:

- 1 1. An apparatus, comprising:
2 an integrated structure having front and rear facets optically connected via a
3 waveguide passing therethrough, the integrated structure further including:
4 a gain section to emit a plurality of photons in response to a first electrical
5 input, having a facet defining the rear facet of the integrated structure;
6 a phase control section disposed adjacent to the gain section, to modulate an
7 optical path length of a portion of the waveguide passing through the control section
8 in response to a second electrical input;
9 a modulator section disposed adjacent to the phase control section, to
10 modulate an optical output passing through a portion of the waveguide passing
11 through the modulator section in response to a third electrical input, and having a
12 facet defining the front facet of the integrated structure; and
13 a partially-reflective mirror disposed between the phase control section and
14 the modulator section.
- 1 2. The apparatus of claim 1, wherein the waveguide is tilted relative to the front and rear
2 facets of the integrated structure.
- 1 3. The apparatus of claim 1, wherein the partially-reflective mirror is oriented
2 substantially perpendicular to a local portion of the waveguide proximate to the mirror.
- 1 4. The apparatus of claim 1, wherein the partially-reflective mirror is effectuated by an
2 air gap defined between the phase control section and the modulator section.

1 5. The apparatus of claim 4, wherein the air gap is etched along a plane that is parallel to
2 a crystalline plane structure of the integrated structure.

1 6. The apparatus of claim 5, wherein the waveguide is bent such that it is substantially
2 perpendicular proximate to the air gap and angled relative to the front and rear facets of the
3 integrated structure.

1 7. The apparatus of claim 4, wherein the air gap is etched along a plane that is angled
2 relative to a crystalline plane structure of the integrated structure.

1 8. The apparatus of claim 4, wherein the partially-reflective mirror comprises a chirped
2 Bragg grating formed along a portion of the waveguide between the gain section and the
3 modulator section.

1 9. The apparatus of claim 1, wherein bandgaps of portions of the waveguide passing
2 through the phase control and modulator sections are broadened approximately 0.06-0.12 eV
3 (electron-volts) relative to a bandgap of the portion of the waveguide passing through the
4 gain section.

1 10 The apparatus of claim 1, wherein portions of the waveguide passing through the
2 phase control and modulator sections comprise an offset quantum-well structure.

1 11. The apparatus of claim 1, wherein portions of the waveguide passing through the
2 phase control and modulator sections comprise a quantum-well intermixed structure.

1 12. The apparatus of claim 1, wherein a portion of the waveguide is configured as
2 asymmetric twin waveguides, wherein the optical functions of amplification and phase
3 control are integrated in separate, vertically coupled waveguides.

1 13. The apparatus of claim 1, wherein the integrated structure is formed from an InGaAsP
2 (Indium-Gallium-Arsenic-Phosphorus) -based semiconductor material.

1 14. A tunable laser, comprising:
2 a base;
3 an integrated structure operatively coupled to the base, having a front facet and a
4 substantially non-reflective rear facet optically coupled via a waveguide passing
5 therethrough, the integrated structure further including:
6 a gain section to emit a plurality of photons in response to a first electrical
7 input, having a facet defining the rear facet of the integrated structure;
8 a phase control section disposed adjacent to the gain section, to modulate an
9 optical path length of a portion of the waveguide passing through the control section
10 in response to a second electrical input; the phase control section having;
11 a partially-reflective mirror, optically coupled to the portion of the waveguide
12 passing through the phase control section;
13 a reflective element, operatively coupled to the base and disposed opposite the
14 substantially non-reflective rear facet to form an external cavity; and
15 a tunable filter including at least one optical element operatively coupled to the base
16 and disposed in the external cavity.

1 15. The tunable laser of claim 14, wherein the waveguide is tilted relative to the rear facet
2 of the integrated structure.

1 16. The tunable laser of claim 14, wherein the front facet of the integrated structure
2 defines the partially-reflective mirror.

1 17. The tunable laser of claim 14, wherein the partially-reflective mirror comprises a
2 chirped Bragg grating formed along a portion of the waveguide in a mirror section adjacent
3 to the phase control section.

1 18. The tunable laser of claim 14, wherein a bandgap of a portion of the waveguide
2 passing through the phase control section is broadened approximately 0.06-0.12 eV
3 (electron-volts) relative to a bandgap of the portion of the waveguide passing through the
4 gain section.

1 19. The tunable laser of claim 14, wherein the portion of the waveguide passing through
2 the phase control section comprises an offset quantum-well structure.

1 20. The tunable laser of claim 14, wherein the portion of the waveguide passing through
2 the phase control section comprises a quantum-well intermixed structure.

1 21. The tunable laser of claim 14, wherein a portion of the waveguide is configured as
2 asymmetric twin waveguides, wherein optical functions of amplification and phase control
3 are integrated in separate, vertically coupled waveguides.

1 22. The tunable laser of claim 14, further comprising a modulator optically coupled to the
2 waveguide at the front facet of the integrated structure.

1 23. The tunable laser of claim 22, wherein the modulator comprises one of an
2 electroabsorption-, Mach-Zehnder-, or directional coupler- based modulator.

1 24. The tunable laser of claim 23, further comprising coupling optics disposed between
2 the modulator and the front facet of the integrated structure and configured to optically
3 couple the modulator to the waveguide.

1 25. The tunable laser of claim 15, wherein the integrated structure is formed from an
2 InGaAsP (Indium-Gallium-Arsenic-Phosphorus) -based semiconductor material.

1 26. A tunable external cavity diode laser (ECDL), comprising:
2 a base;
3 an integrated structure operatively coupled to the base, having a front facet and a
4 substantially non-reflective rear facet optically coupled via a waveguide passing
5 therethrough, the integrated structure further including:
6 a gain section to emit a plurality of photons in response to a first electrical
7 input, having a facet defining the rear facet of the integrated structure;
8 a phase control section disposed adjacent to the gain section, to modulate an
9 optical path length of a portion of the waveguide passing through the control section
10 in response to a second electrical input;
11 a modulator section disposed adjacent to the phase control section, to
12 modulate an optical output passing through a portion of the waveguide passing
13 through the modulator section in response to a third electrical input, having a facet
14 defining the front facet of the integrated structure; and
15 a partially-reflective mirror disposed between the phase control section and
16 the modulator section.
17 a reflective element, operatively coupled to the base and disposed opposite the
18 substantially non-reflective rear facet to form an external cavity; and

19 a tunable filter including at least one optical element operatively coupled to the base
20 and disposed in the external cavity.

1 27. The tunable ECDL of claim 26, further comprising a cooling element thermally
2 coupled to the integrated structure.

1 28. The tunable ECDL of claim 26, wherein the partially-reflective mirror is effectuated
2 by a gap formed between the phase control section and the modulator section.

1 29. The tunable ECDL of claim 26, wherein the partially-reflective mirror comprises a
2 chirped Bragg grating formed along a portion of the waveguide between the gain section and
3 the modulator section.

1 30. The tunable ECDL of claim 26, wherein bandgaps of portions of the waveguide
2 passing through the phase control and modulator sections are broadened approximately 0.06-
3 0.12 eV (electron-volts) relative to a bandgap of the portion of the waveguide passing
4 through the gain section.

1 31. The tunable ECDL of claim 26, further comprising a controller to supply control
2 inputs to the gain section, phase control section, and the tunable filter.

1 32. The tunable ECDL of claim 31, wherein the tunable filter comprises first and second
2 tunable filters.

1 33. The tunable ECDL of claim 32, wherein each of the first and second tunable filters
2 comprises thermally-tunable etalons, and the controller provides inputs to control the
3 temperature of each thermally-tunable etalon.

1 34. The tunable ECDL of claim 26, wherein the tunable filter comprises a Vernier tuning
2 mechanism including respective first and second optical filters having respective sets of
3 transmission peaks having slightly different free spectral ranges and similar finesses, and
4 wherein tuning is performed by shifting the set of transmission peaks of the second optical
5 filter relative to the set of transmission peaks of first optical filter to align a single
6 transmission peak of each of the first and second sets of transmission peaks.

1 35. A telecommunication switch comprising:
2 a plurality of fiber line cards, each including,
3 a multi-stage multiplexer/demultiplexer;
4 a circulator bank, comprising a plurality of circulators operatively coupled to
5 the multi-stage multiplexer/demultiplexer;
6 a receiver bank, comprising a plurality of receivers operatively coupled to
7 respective circulators; and
8 a transmitter bank, comprising a plurality of transmitters operatively coupled
9 to respective circulators, each transmitter comprising a tunable external cavity diode
10 laser (ECDL), including:
11 a base;
12 an integrated structure operatively coupled to the base, having a front
13 facet and a substantially non-reflective rear facet optically coupled via a
14 waveguide passing therethrough, the integrated structure further including:
15 a gain section to emit a plurality of photons in response to a
16 first electrical input, having a facet defining the rear facet of the
17 integrated structure;

18 a phase control section disposed adjacent to the gain section, to
19 modulate an optical path length of a portion of the waveguide passing
20 through the control section in response to a second electrical input;
21 a modulator section disposed adjacent to the phase control
22 section, to modulate an optical output passing through a portion of the
23 waveguide passing through the modulator section in response to a third
24 electrical input, having a facet defining the front facet of the integrated
25 structure; and
26 a partially-reflective mirror disposed between the phase control
27 section and the modulator section.
28 a reflective element, operatively coupled to the base and disposed
29 opposite the substantially non-reflective rear facet to form an external cavity;
30 and
31 a tunable filter including at least one optical element operatively
32 coupled to the base and disposed in the external cavity.
33

1 36. The telecommunications switch of claim 35, wherein at least one ECDL employs a
2 Vernier tuning mechanism including respective first and second optical filters having
3 respective sets of transmission peaks having slightly different free spectral ranges and similar
4 finesses, and wherein tuning is performed by shifting the set of transmission peaks of the
5 second optical filter relative to the set of transmission peaks of first optical filter to align a
6 single transmission peak of each of the first and second sets of transmission peaks.

1 37. The telecommunications switch of claim 36, wherein the first and second optical
2 filters comprise respective thermally-tunable etalons.